in the genus Eutænia, where difference of locality has had such an effect on the coloration as to give rise to several species being made out of the common garter snake.

I have procured these newts from many places in New York and New Jersey States and different parts of Long Island, of every shade of red up to very bright scarlet, yet within a radius of many miles from Brooklyn, where the *viridescens* and its variety are both plentiful, I never find the latter other than a reddish-brown, varying from light to very dark. Sometimes late in December I find little brown ones with flame-colored spots, in the ponds. These are so greatly attenuated it is possible they have returned to the water in search of food, lacking on land, at so late a period when all animal life which would be available for them disappears from the surface.

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## THE RELATION OF THE PECTORAL MUSCLES OF BIRDS TO THE POWER OF FLIGHT.

BY CHARLES L. EDWARDS.

OF all the modes of animal locomotion flight is the most rapid, the most graceful, the most fascinating. With one important exception this power separates the bird from the other vertebrates and gives it preëminence in motion. Its whole structure—the conical form of the body offering so little resistance to the air, the hollow bones, the air-sacs and the weaving together of the smallest barbules to form the close web of the wing—all denote that in the air, in flight, is the bird's life.

While in a very general way much has been observed with regard to the variation in the power of flight of species differing quite widely from each other, yet there are still some unsolved problems connected with the highest form of motion.

Before attempting the solution of any special problem there are certain mechanical elements of flight with which we must become familiar.

A body much heavier than air is to be propelled with great speed through the air. The resistances are the force of gravity and the air itself.

The perpendicular action of the broadly expanded wings opposes as much as possible the force of gravity, while the narrow

wing-line and the cleaving form of the conical body reduce as much as possible the resistance of the air in front.

The cause of motion is the action of the wings upon the highly elastic air producing by reaction forward movement of the body. The source of this action is in the pectoral muscles. Its instruments are the wings. Wonderfully indeed are the wings adapted to their purpose. Of extreme lightness and of great rigidity and strength, their weight is but a slight hindrance and their leverage a vast advantage in producing motion.

Concave beneath and convex above, with underlapping feathers, to the one side is presented a grasping surface almost impervious to air, and to the other a lattice-work structure through which air easily rushes. So in the depression of the wing all possible advantage is gained from the elastic resistance of the air, and in its elevation the least amount of force is lost.

The muscles which furnish the propelling force to the wings are those of the breast, the pectoralis major and the pectoralis minor. The pectoralis major is a large, triangular muscle forming the principal part of the bulk of the breast. It arises from the ribs, from the outer portion of the ventral surface of the sternum, from the side of the keel of the sternum, from the furculum and the membrane connecting the furculum with the sternum and the coracoid. The fibers converge, the outer turning under the inner and inserted by a tendon on the greater tuberosity of the humerus. In action this muscle depresses the wing and thus furnishes the great motive power of flight.

The pectoralis minor is much smaller than the preceding, and beneath it; arising from the middle portion of the sternum and the membrane attaching the furculum to the sternum and the coracoid. Its fibers converging terminate in a tendon which, after passing through the end of the coracoid, is inserted on the inner side of the greater tuberosity of the humerus. This muscle, together with the resisting force of the air, elevates the wing after it has been depressed.

From the structure of the wing it is apparent that the work of this muscle is relatively small except, perhaps, in "sailing," as seen in the flight of swallows, where the wings must be held tense and at a constant angle by this muscle. It would clearly appear, when we consider the law of muscular development, that in those species which fly most of these muscles would be rela-

tively larger than in those of less power of flight. Conversely, other things being constant, those birds in which the pectoral muscles form a larger percentage of the weight of the body, would have a greater power of flight.

This being true the question naturally rises: What is the variation in the development of the pectoral muscles for the different species of birds, and is this variation by natural families or by individual species?

In the solution of our problem the shape of the wing plays an important part. The long, narrow, sharp-pointed wing is most advantageous to continued flight, and the shorter, rounded, less-compact form is least so. Between these two extremes there is an indefinite shading of the one form into the other, with more or less resulting advantage as the case may be.

The pectoral muscles may be relatively large, yet if the wing be of impeding form, so that considerable force is lost in overcoming the consequent disadvantage, the resulting power of flight is much lessened.

In this paper I have taken the weight of the whole body as a constant basis and found the percentage by weight of the pectoral muscles in the body. The data are derived from the dissection of 119 birds, having in all cases possible taken an average for each species from three individuals.

There are represented seven orders, twenty-five families and fifty-three species. It will be seen that variation is not by natural families but by individual species. This is explained by the fact that though certain species may have structures so allied as to join them together in a family, yet because of their distinct habits of life they may differ considerably in their power of flight.

List of species examined, arranged in order of percentage of pectoral muscles to total weight of body:

| | | | |
|---|---|---|---|
| Broad-winged hawk.....5.98 per cent. *Buteo pennsylvanicus.* | | Maryland yellow-throat....7.50 per cent. *Geothlypis trichas.* | |
| Screech owl.....6.14 | " | Blue-jay.....7.68 | " |
| *Scops asio.* | | *Cyanocitta cristata.* | |
| Mallard duck.....6.68 | " | Song sparrow.....7.84 | " |
| *Anas boschas.* | | *Melospiza fasciata.* | |
| House wren.....6.87 | " | Mud hen or coot.....7.89 | " |
| *Troglodytes ædon.* | | *Fulica americana.* | |
| Cat-bird.....7.12 | " | Brown thrush.....8.00 | " |
| *Mimus carolinensis.* | | *Harporhynchus rufus.* | |

Loggerhead shrike.....8.04 per cent.
*Lanius ludovicianus excubitorides.*

Red-headed woodpecker...8.21 per cent.
*Melanerpes erythrocephalus.*

White-throated sparrow....8.31 "
*Zonotrichia albicollis.*

Chewinck.....8.60 "
*Pipilo erythrophthalmus.*

Olive-backed thrush.....8.73 "
*Hylocichla ustulata swainsoni.*

Cliff swallow.....8.74 "
*Petrochelidon lunifrons.*

Summer warbler.....8.76 "
*Dendræca æstiva.*

White-bellied nuthatch.....9.03 "
*Sitta carolinensis.*

Purple martin.....9.19 "
*Progne subis.*

Ruddy duck.....9.33 "
*Erismatura rubida.*

Orchard oriole.....9.42 "
*Icterus spurius.*

Baltimore oriole.....9.51 "
*Icterus galbula.*

Blue-winged teal.....9.58 "
*Querquedula discors.*

Rose-breasted grosbeak.....9.66 "
*Habia ludoviciana.*

Titmouse.....9.78 "
*Parus atricapillus.*

Fox sparrow.....9.87 "
*Passerella iliaca.*

Snow-bird..... 9.97 "
*Junco hyemalis.*

Crow blackbird..... 9.99 "
*Quiscalus versicolor.*

Belted kingfisher.....10.03 "
*Ceryle alcyon.*

Tree sparrow.....10.03 "
*Spizella monticola.*

Blue-bird.....10.05 "
*Sialia sialis.*

Gold'n-wing'd w'dpecker10.09 per cent.
*Colaptes auratus.*

Wild goose.....10.22 "
*Branta canadensis.*

Meadow lark.....10.34 "
*Sturnella magna.*

Red-eyed vireo.....10.40 "
*Vireosylvia olivacea.*

Field sparrow.....10.55 "
*Spizella pusilla.*

Scarlet tanager.....10.65 "
*Pyranga rubra.*

Chimney swift.....10.75 "
*Chætura pelagica.*

Pigeon.....11.09 "
*Ectopistes migratorius.*

Chipping sparrow.....11.14 "
*Spizella socialis.*

Black-throated bunting..11.23 "
*Euspiza americana.*

Robin.....11.41 "
*Turdus migratorius.*

American goldfinch.....11.43 "
*Astragalinus tristis.*

Cow-bird.....11.50 "
*Molothrus ater.*

King-bird.....11.61 "
*Tyrannus carolinensis.*

Wood duck.....11.91 "
*Aix sponsa.*

Wood pewee.....12.10 "
*Contopus virens.*

Green-winged teal.....12.14 "
*Nettion carolinense.*

Shore lark.....13.32 "
*Otocoris alpestris.*

Quail.....14.99 "
*Ortyx virginianus.*

Ruffed grouse.....15.51 "
*Bonasa umbellus.*

Mourning dove.....16.33 "
*Zenædura carolinensis.*

From the following comparisons of the hen and the goose with the nearest allied wild species which I have been enabled to ob-

tain, the results of domestication as affecting pectoral development is readily seen:

| | | |
|---|---|---|
| Ruffed grouse (*Bonasa umbellus*) | 15.51 | per cent. |
| Hen | 4.66 | " |
| Wild goose (*Branta canadensis*) | 10.22 | " |
| Tame goose | 6.40 | " |

I do not claim that from this list the exact place of a bird can be given as to its power of flight, because other elements than the size of the pectoral muscles enter into this complex problem so as to preclude an absolute classification on the basis of pectoral development, yet I think that there is a relative variation expressed by the figures given in this list, and that when together with this element the other elements of flight are considered we can tell the place a bird should occupy in the scale of flight.

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## GEOLOGICAL EXTINCTION AND SOME OF ITS APPARENT CAUSES.

BY A. S. PACKARD.

IN his Origin of Species, Darwin says: "The extinction of species has been involved in the most gratuitous mystery. Some authors have even supposed that, as the individual has a definite length of life, so have species a definite duration. No one can have marveled more than I have done at the extinction of species." Finally, he remarks, "Thus, as it seems to me, the manner in which single species and whole groups of species become extinct accords wells with the theory of natural selection. We need not marvel at extinction; if we must marvel, let it be at our own presumption in imagining for a moment that we understand the many complex contingencies, on which the existence of each species depends. If we forget, for an instant, that each species tends to increase inordinately, and that some check is always in action, yet seldom perceived by us, the whole economy of nature will be utterly obscured. Whenever we can precisely say why this species is more abundant in individuals than that; why this species and not another can be naturalized in a given country; then, and not till then, we may justly feel surprised why we cannot account for the extinction of any particular species or any group of species."

The fact of extinction is indeed not less marvelous than that